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ORIGINAL ARTICLE

WILEY

The structural validity of the IKDC and its relationship with quality of life following ACL reconstruction

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Objective: The purpose of this study was to (a) examine the structural validity of the International Knee Documentation Committee Subjective Knee Form in light of previously reported dimensionality issues, and (b) examine the relationships between the IKDC and patients' knee-related quality of life 2-9 years after anterior cruciate ligament (ACL) reconstruction.

Methods: A prospective research design was employed, wherein 319 patients (mean age = 29.07, *SD* = 9.03) completed the IKDC before surgery, 191 patients (mean age = 29.71, *SD* = 9.36) completed the IKDC at 6 months post-surgery, and 132 patients (mean age = 34.34, *SD* = 7.89) completed the IKDC and the Anterior Cruciate Ligament Quality of Life Survey (ACL-QOL) at 2-9 years post-surgery.

Results: Bayesian structural equation modeling analysis confirmed the two-factor structure (*symptom & knee articulation* and *activity level*) represented the most accurate conceptualization of perceived knee function across the three time-points. Moreover, findings revealed that of the two IKDC subscales pre-operatively, activity level was most strongly associated with long-term quality of life at 2-9 years following surgery, whereas 2-9 years post-operatively, symptoms and knee articulation was most strongly associated with long-term quality of life.

Conclusions: The IKDC provides clinicians with a convenient total score to assess patients' perceived knee function, but its unidimensional factor structure is a poor representation of its items and fails to detect discrepancies in patients' post-operative quality of life, such as the relative importance of perceived knee activity level before reconstructive surgery.

KEYWORDS

anterior cruciate ligament, Bayesian structural equation modeling, perceived knee function, quality of life

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1 | INTRODUCTION

It is important to adopt a multiplicity of assessments, which include both functional performance testing and patient-reported measures, to comprehensively evaluate patients' outcomes following anterior cruciate ligament (ACL) reconstruction.[1] Of the patient-reported outcome measures that exist, the International Knee Documentation Committee Subjective Knee Form (IKDC[2]) is one of the most widely used in clinical practice, and orthopedic and sport injury research.[3-5] The IKDC is an 18-item, region-specific instrument designed to measure symptoms, function, and sports-related activity. The symptom items assess pain, stiffness, swelling, joint-locking, and instability. The function items assess an individual's ability to perform activities of daily living, while the sport-related activity items assess an individual's ability to run, jump and land, stop and start quickly, ascend and descend stairs, stand, kneel on the front of the knee, squat, sit with their knee bent, and rise from a chair.

Even though the IKDC has been used extensively, there has, and continues to be, some debate regarding its factor structure.[6-8] In its original conceptualization, Irrgang et al[2] proposed a one-factor structure, combining the three constructs of symptoms, functions, and sports-activity into one total score. Despite non-significant factor loadings for three items (suggesting those items were either poor indicators of the construct, or were in fact measuring something other than the construct of interest), they retained all the items in the final version "to ensure adequate content coverage for a variety of knee conditions" (p. 606). However, subsequent studies (eg,[8]) have failed to support a unidimensional factor structure, with Grevnerts et al[6] concluding that the IKDC is more likely to be multifactorial.

Despite these contrasting positions, only one study to date has examined the multifactorial structure of the IKDC. Higgins et al's[7] study with patients with a wide variety of knee-related disorders, concluded that a two-factor solution (symptom and knee articulation, SKA; and activity level, AL) resulted in the least ambiguous separation between factors, but that future validation studies should be conducted to confirm this multifactorial structure, examine the test-retest reliability of the instrument, and analyze the responsiveness of the instrument to changes in knee function across time. This, to the best of our knowledge, has not been addressed.

The use of a psychometrically robust outcome measure of perceived knee function is crucial for clinicians and researchers alike. A patient's perceived knee function is associated with a number of recovery outcomes, including a fear of re-injury,[9] and a readiness to return to sport,[10] both of which have been identified as risk factors in failing to return to sport[4] and sustaining a second ACL injury upon return.[11] Furthermore, failing to return to sport and subsequent injury have been shown to detrimentally affect patients' long-term quality of life.[12]

Recently, a number of factors have been associated with individuals' knee-related quality of life, including osteoarthritis, subsequent injuries, fear of re-injury, lifestyle modifications, and pre-injury activity level.[12,13] Yet, the findings on the relationship between perceived knee function and patients' long-term health-related quality of life are limited and, at best, contradictory.[14] Therefore, the purpose of this study was twofold. Firstly, to examine the psychometric integrity and the multifactorial structure of the IKDC across time. Secondly, to examine the relationship between patients' perceived knee function and knee-related quality of life up to 9 years post-ACL surgery.

2 | METHODS

2.1 | Participant recruitment

A convenience sample of 384 patients who had undergone primary ACL reconstruction with a single experienced orthopedic surgeon in the United Kingdom between 2008 and 2016 were identified from the surgical records. Individuals were considered eligible if they: (a) were undergoing primary ACL reconstruction; (b) were aged over 18 at the time of recruitment; (c) were fluent in written English; and (d) had completed at least the pre-surgery IKDC measure. Participants undergoing revision surgery and/or additional procedures other than simple meniscal/chondral surgery, and participants with incomplete responses on the pre-surgery IKDC were excluded.

2.2 | Measures

2.2.1 | Knee function

The 18-item IKDC measures symptoms of pain, ligament deficiency, and function. Examples of questions include, "What is the highest level of activity that you can perform without significant knee pain?", "What is the highest level of activity you can perform without significant giving way in your knee?", and "What is the highest level of activity you can participate in on a regular basis?" Responses to items are made on a combination of 5-point Likert scales, 11-point Likert scales, and dichotomous "yes-no" responses, which yield a total knee function score out of 100. Internal consistency coefficients (Cronbach's alpha) of 0.92 and test-retest reliability of 0.94 have been reported for the IKDC as a total score.[2]

2.2.2 | Quality of life

The Anterior Cruciate Ligament Quality of Life Survey (ACL-QOL[15]) was used to measure quality of life following ACL reconstruction. The ACL-QOL comprises 32-items which reflect five subscales: symptoms and physical complaints ($n_{items} = 5$; eg, "How much are you troubled by stiffness or loss of motion in your knee"), work-related ($n_{items} = 4$; eg, "How much trouble do you have, because of your knee, with turning or pivoting motions at work"), recreational activity and sport participation/competition ($n_{items} = 12$; eg, "How does your current level of athletic or recreational performance compare with your pre-injury level"), lifestyle ($n_{items} = 6$; eg, "How much has your enjoyment of life been limited by your knee problem"), and social and emotional ($n_{items} = 5$; eg, "Have you had difficulty being able to psychologically "come to grips" with your knee problem"). Each item is answered on a 100-point visual analogue scale; however, this was replaced in the present study with a numerical rating scale from 0-100 to enable online completion. Subscale scores are computed from the mean of the category items, and a total ACL-QOL score represents a mean of all the subscales. Evidence of the measure's reliability (reproducibility), responsiveness/detection of clinically important change, and face, content, and construct validity have all been supported (eg, [15,16]).

2.3 | Procedure

The study adopted a longitudinal research design with data collected at three time-points: pre-surgery, 6 months post-surgery, and 2-9 years post-surgery. Participants completed the IKDC, administered in hard copy, at their pre-surgery consultation (typically one week before surgery). At 6 months post-surgery, these participants were invited to complete the IKDC once more at their follow-up appointment with their surgeon. Following institutional approval from the Cardiff School of Sport and Health Sciences (Cardiff Metropolitan University) ethics committee, participants who had completed the pre-surgery and 6 months post-surgery measures were then contacted via telephone and/or email, explained the purpose of the study, including how the data they had previously provided would be used, and invited to participate. Those who had completed the pre-surgery and 6 months post-surgery measures were sent a link, via email, to an online survey containing further information, a consent form, and the online versions of the ACL-QOL and IKDC. All participants provided informed consent before completing the online questionnaires.

2.4 | Data analysis

Bayesian structural equation modeling (BSEM; cf.[17]) was used to (a) test the factor structure of the IKDC; and (b) examine the relationships between the IKDC and ACL-QOL. Bayesian estimation was employed in this study because it offers a more flexible analytic approach to overcome the highly restrictive features commonly applied within confirmatory factor analysis (CFA), in which indicators are free to load on their intended factors, and cross-loadings and residual correlations are fixed at zero. This can be argued to be a strongly simplified representation of real measurement situations, which almost always leads to the rejection of the model by the likelihood ratio chi-squared test.[18] Instead, BSEM enables researchers to model uncertainty in their specifications by replacing exact zero parameters with approximate zeros (ie, zero mean, small variance). In doing so, indicators have a major loading on a hypothesized factor, but small cross-loadings are possible due to a minor influence from other factors, better reflecting substantive theories.[19]

The data were standardized before the estimation of each confirmatory model followed three similar stages. The first stage incorporated non-informative priors for the major loadings, exact zero cross-loadings, and exact zero residual correlations. The second stage included the addition of informative approximate zero cross-loadings, while the final stage incorporated both informative approximate zero cross-loadings and residual correlations. Within this Bayesian estimation the model convergence was examined using the MCMC simulation procedure with a Gibbs sampler,[19] a fixed number of 100 000 iterations, and the potential scale reduction factor (PSR), where evidence for convergence is demonstrated when the PSR lies between 1.0 and 1.1 for all parameters.[20] The posterior predictive *P* value (PPP value) and 95% confidence interval for the difference in the observed and replicated χ^2 values are used to assess model fit. A good fitting model is indicated when the PPP values are around 0.50, the 95% confidence interval values center on zero, and the items have significant factor loadings (>0.40).[19-21] The deviance information criterion (DIC) value is also used to compare measurement invariance models in the Bayesian estimation, in which a lower value indicates a better fitting model.[17]

3 | RESULTS

3.1 | Participant characteristics

Of the eligible participants, 319 (mean age = 29.07, SD = 9.03; male 82%, female 18%; hamstring tendon autograft, 86%, patellar tendon-bone autograft, 14%) participated at Time 1. The sample at Time 2 (6 months post-surgery) comprised 191 participants (mean age = 29.71, SD = 9.36; male, 80%, female, 20%; hamstring tendon autograft, 86%, patellar tendon-bone autograft, 14%). Finally, the sample at Time 3 (participants at 2-9 years post-surgery) consisted of 132 participants (mean age = 34.34, SD = 7.89; male, 67%, female 33%, hamstring tendon autograft, 81%, patellar tendon-bone autograft, 19%; and participated at recreational, 34%, club, 32%, regional, 24%, and national, 10% levels of sport at the time of their injury.[1]

[1]Participants' pre-injury playing level was not collected at Time 1 and Time 2.

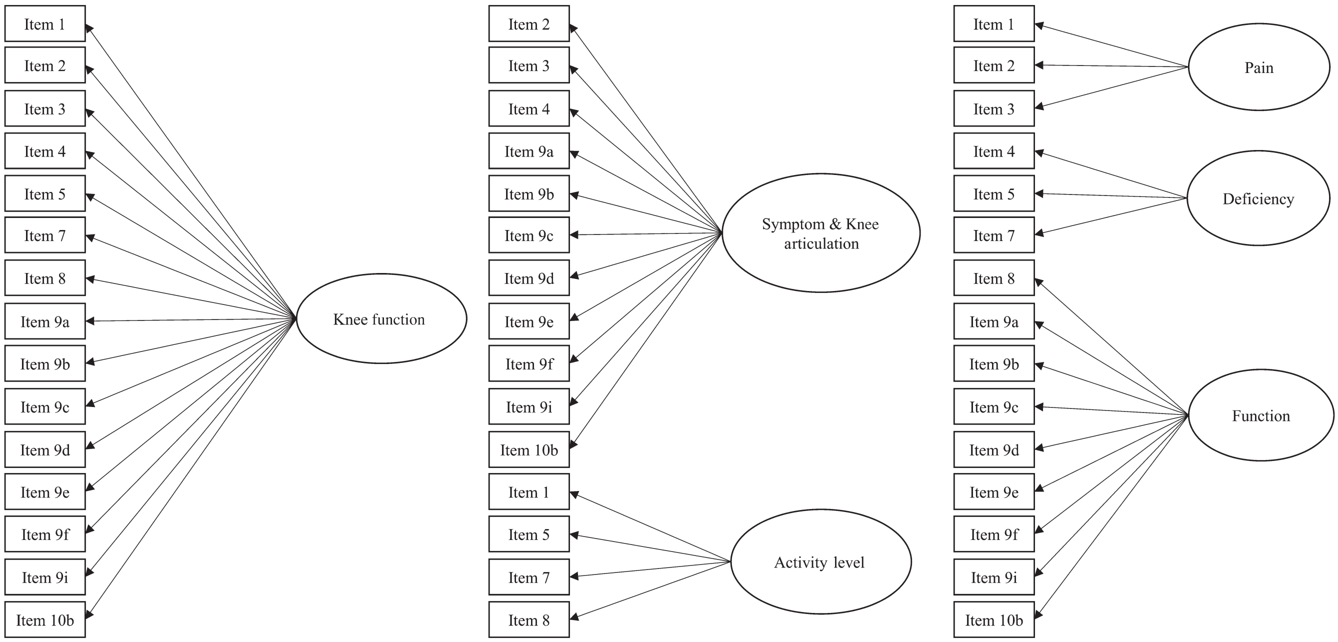

FIGURE 1 The hypothesized factor loading pattern for the one-factor, two-factor, and three factor IKDC models

3.2 | Structural validity

In response to debates around the factor structure of the IKDC (as outlined in the introduction), comparative one-factor, two-factor, and three-factor models were tested on the 15-items Higgins et al[7] suggested should be retained in all subsequent validation studies (the items that were retained in the one-factor, two-factor, and three-factor model are presented in Figure 1). The two-factor solution reflected that suggested by Higgins et al[7] and consisted of symptom and knee articulation (n_{items} = 11) and activity level (n_{items} = 4), while the three-factor solution, which we considered offered greater conceptual integrity and face validity based on the content of the items, represented pain (n_{items} = 3), deficiency (n_{items} = 3), and function (n_{items} = 11). The BSEM fit statistics for the one-factor, two-factor, and three-factor solutions are displayed in Table 1. BSEM with informative priors on the cross-loadings (two-factor and three-factor models) and residual correlations (one-factor, two-factor, and three-factor models) revealed excellent fit to the data for each of the models, with a PPP > 0.5. However, inspection of the standardized factor loadings for the three-factor model revealed that a number of items failed to load significantly onto their intended factor.[2] In contrast, all

TABLE 1 BSEM fit statistics for the IKDC scale

Model	PPP	Lower 2.5% CI	Upper 2.5% CI	DIC
Time 1 (n = 319)				
15-item one-factor scale	0.511	−45.794	45.022	11594.807
15-item two-factor scale	0.534	−47.531	44.839	11590.231
15-item three-factor scale	0.548	−47.510	43.633	11585.864
Time 2 (n = 191)				
15-item one-factor scale	0.529	−49.032	45.024	6683.328
15-item two-factor scale	0.564	−50.777	42.815	6677.921
15-item three-factor scale	0.558	−49.976	43.012	6673.553
Time 3 (n = 132)				
15-item one-factor scale	0.554	−50.501	43.577	4646.933
15-item two-factor scale	0.592	−51.989	41.625	4639.929
15-item three-factor scale	0.575	−51.813	43.000	4636.101

Abbreviations: DIC, deviance information criteria; PPP, posterior predictive *P* value.

[2]***Pain item 1*** (Time 1: CI = [−0.16, 0.27]; Time 2: CI = [−0.05, 0.27]) had non-significant factor loadings (<0.20) at Time 1 and 2. ***Deficiency item 5*** (Time 1: CI = [−0.01, 0.63]; Time 2: CI = [−0.14, 0.38]) and ***item 7*** (Time 1: CI = [−0.21, 0.49]; Time 2: CI = [−0.17, 0.34]) had non-significant factor loadings (<0.35) at Time 1 and 2. ***Function item 8*** (Time 1: CI = [−0.11, 0.24]; Time 2: CI = [−0.07, 0.25]) had non-significant factor loadings (<0.20) at Time 1 and 2. ***Function item 9c*** (Time 2: CI = [−0.26, 0.68]) and ***item 10b*** (Time 2: CI = [−0.14, 0.57]) had non-significant factor loadings (<0.35) at Time 2.

major loadings for the one-factor and two-factor model were greater than Hu and Bentler's[21] cutoff (>0.40) and significant across all three time-points (the factor loadings for the two-factor model are presented in Table 2). However, in comparison with the one-factor model, the two-factor model demonstrated considerably better fit (ie, higher PPP value and a lower DIC value[17]). Furthermore, a sensitivity analysis revealed no important discrepancies between parameter estimates when varying the a priori distribution for cross-loadings and residual covariance. Consequently, and in accordance with Higgins et al,[7] a 15-item two-factor IKDC scale was retained for the remainder of the analysis.

3.3 | Descriptive statistics

The extent to which quality of life and knee function differed because of the demographic variables (age, gender, graft type, years since surgery, pre-injury playing level) was assessed using five separate MANOVA's. This revealed no significant multivariate effects of age, gender, graft type, or pre-injury playing level. However, there was a significant multivariate effect for years since surgery; Wilks' Lambda $F(14, 246) = 2.17$, $P = .01$. In light of these findings, years since surgery was controlled for in the analyses involving variables assessed at Time 3. Furthermore, Hotelling's T^2 test revealed a statistically significant difference between those participants that remained in the study compared to those that dropped out ($T^2 = 130.29$, $F(5,313) = 25.71$, $P < .0005$). Specifically, those that remained in the study had significantly higher AL ($P = .01$) and SKA ($P = .01$) pre-surgery.

3.3.1 | Bivariate correlations

Means, standard deviations, internal reliability, and bivariate correlations are displayed in Table 3. Symptom and knee articulation was significantly correlated across time and activity level was also significantly correlated across time. Symptom and knee articulation was significantly and positively correlated with activity level, symptoms, lifestyle, and social and emotional across time. In addition, symptom and knee articulation was significantly and positively correlated with work and recreational activity and sport participation/competition across time, except for symptom and knee articulation at Time 1, which were not significant. Activity level was significantly and positively correlated with symptoms, work, recreational activity and sport participation/competition, lifestyle, and social and emotional across time. Furthermore, each of the quality of life subscales was significantly and positively correlated with one another.

3.4 | The relationships between the IKDC and ACL-QOL

To examine the relationships between the IKDC and ACL-QOL, symptoms and knee articulation (SKA) and activity

TABLE 2 Standardized factor loadings for the 15-item 2-factor IKDC scale

	Symptom and knee articulation			Activity level		
Item	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
IKDC-2	**0.57****	**0.69****	**0.70****	0.02	−0.02	0.03
IKDC-3	**0.54****	**0.69****	**0.79****	0.00	−0.04	−0.03
IKDC-4	**0.49****	**0.57****	**0.70****	0.03	0.00	−0.01
IKDC-9a	**0.74****	**0.72****	**0.69****	0.02	−0.03	−0.02
IKDC-9b	**0.76****	**0.71****	**0.68****	0.02	0.02	0.00
IKDC-9c	**0.73****	**0.59****	**0.63****	0.01	0.01	0.03
IKDC-9d	**0.76****	**0.74****	**0.77****	−0.05	0.01	−0.02
IKDC-9e	**0.58****	**0.53****	**0.64****	−0.05	0.01	0.01
IKDC-9f	**0.66****	**0.70****	**0.69****	−0.02	−0.05	0.00
IKDC-9i	**0.59****	**0.68****	**0.73****	0.05	0.05	−0.01
IKDC-10b	**0.51****	**0.65****	**0.70****	0.03	0.09	0.08
IKDC-1	−0.05	−0.03	−0.04	**0.86****	**0.92****	**0.87****
IKDC-5	0.10	0.05	0.03	**0.75****	**0.81****	**0.82****
IKDC-7	0.00	−0.01	0.00	**0.82****	**0.87****	**0.84****
IKDC-8	−0.01	0.03	0.05	**0.83****	**0.83****	**0.81****

Bold values indicate loadings for their respective factors.

**$P < .01$.

level (AL) were modeled as predictors of symptoms, work, recreational activity, lifestyle, and social and emotional (ACL-QOL) in three separate BSEMs.[3]

3.4.1 | Pre-surgery IKDC

The results revealed that AL demonstrated significant associations with symptoms (β = 0.35, P = .003, CI [.12, 0.58]), work (β = 0.28, P = .010, CI [.05, 0.52]), recreational activity (β = 0.37, P = .002, CI [.13, 0.60]), lifestyle (β = 0.35, P = .002, CI [.12, 0.58]), and social and emotional (β = 0.34, P = .003, CI [.11, 0.57]). SKA was not associated with symptoms (β = 0.04, P = .366, CI [−0.22, 0.28]), work (β = −0.07, P = .296, CI [−0.32, 0.17]), recreational activity (β = −0.07, P = .297, CI [−0.33, 0.18]), lifestyle (β = 0.06, P = .305, CI [−0.19, 0.30]), and social and emotional (β = 0.08, P = .245, CI [−0.17, 0.31]). Collectively, SKA and AL accounted for a significant amount of variance in symptoms (R^2 .15, P = .03) recreational activity (R^2 .12, P = .04), lifestyle (R^2 .16, P = .03), and social and emotional (R^2 .17, P = .03). SKA and AL did not account for a significant amount of variance in work (R^2 .07, P = .11).

3.4.2 | Six months post-surgery IKDC

SKA and AL both demonstrated significant associations with symptoms (βs = 0.57 and 0.34, Ps = .004 and 0.014, CI [.32, 0.79] and [.08, 0.57] respectively), recreational activity (βs = 0.41 and 0.42, P = .021 and 0.003, CI [.04, 0.62] and [.19, 0.75], respectively), lifestyle (βs = 0.50 and 0.32, P = .007 and 0.015, CI [.22, 0.73] and [.06, 0.57], respectively), and social and emotional (βs = 0.48 and 0.38, P = .011 and 0.008, CI [.19, 0.70] and [.13, 0.64], respectively). SKA demonstrated a significant association with work (β = 0.53, P = .002, CI [.29, 0.84]), but AL was not significantly associated with work (β = 0.15, P = .136, CI [−0.21, 0.39]). Together, SKA and AL significantly predicted variance in symptoms (R^2 .70, P < 0.001), work (R^2 .42, P < .001), recreational activity (R^2 .58, P < .001), lifestyle (R^2 .57, P < .001), and social and emotional (R^2 .62, P < .001).

3.4.3 | Two to nine years post-surgery IKDC

The results revealed that SKA demonstrated significant associations with symptoms (β = 0.69, P = .002, CI [.48, 0.96]), work (β = 0.55, P = .009, CI [.24, 0.88]), lifestyle (β = 0.63, P = .007, CI [.37, 0.91]), and social and emotional (β = 0.63, P = .006, CI [.36, 0.90]). AL was not associated with symptoms (β = 0.29, P = .029, CI [−0.02, 0.51]), work (β = 0.21, P = .088, CI [−0.16, 0.51]), lifestyle (β = 0.27, P = .039, CI [−0.06, 0.52]), and social and emotional (β = 0.29, P = .029, CI [−0.02, 0.55]). SKA and AL both demonstrated significant associations with recreational activity (βs = 0.53 and 0.36, P = .017 and 0.012, CI [.14, 0.79] and [.08, 0.73], respectively). In total, SKA and AL significantly predicted variance in symptoms (R^2 .85, P < .001), work (R^2 .52, P < .001), recreational activity (R^2 .69, P < .001), lifestyle (R^2 .71, P < .001), and social and emotional (R^2 .74, P < .001).

4 | DISCUSSION

The purpose of this study was twofold. Firstly, the multifactorial structure of the IKDC was examined in light of theoretical concerns and non-significant factor loadings associated with its original unidimensional conceptualization.[2] Secondly, we examined the relationships between the IKDC and patients' reported quality of life 2-9 years after ACL reconstruction at three time-points: (a) pre-ACL reconstruction, (b) 6 months post-ACL reconstruction, and (c) 2-9 years post-ACL reconstruction. In the first phase of the study, Bayesian CFA with small variance priors on the cross-loadings and residual correlations produced an excellent model-data fit for the two-factor IKDC scale proposed by Higgins et al[7] at each of the three time-points. Furthermore, Higgins et al's[7] two-factor solution was superior to the original one-factor structure proposed by Irrgang et al[2] and an alternative three-factor solution which we felt represented greater conceptual integrity of the items. These results, in conjunction with Higgins et al's,[7] suggest the IKDC scale should be conceptualized with two factors: (a) symptoms and knee articulation and (b) activity level.

In the second phase of the study, the findings demonstrated that participants' quality of life was similar, irrespective of their age, gender, graft type, or pre-injury playing levels. Although similar findings have been reported for age,[14,22] gender,[14-23] and graft type,[24-26] they contrast with those of Filbay et al[12] who suggested that people engaged in highly competitive sport might be at increased risk of poor quality of life. With respect to the predictive relationships between the IKDC and ACL-QOL, the most meaningful findings related to the changing associations between the IKDC and ACL-QOL subscales at the three time-points. Specifically, pre-surgery AL demonstrated significant predictive relationships with all five ACL-QOL subscales, whereas SKA did not (although positive correlations were evident between pre-surgery SKA and three ACL-QOL subscales). At 6 months post-surgery, AL was significantly associated with four out of five ACL-QOL components (only *work* was not), while SKA was significantly associated with all five

[3]The BSEM results with weighted scores for each of the IKDC items can be obtained from the first author.

TABLE 3 Means (*M*), standard deviations (SD), internal reliability (α), and bivariate correlations between observed variables across all three time-points

Variable	*M*	SD	α	1	2	3	4	5	6	7	8	9	10	11
Time 1														
1. Symptom and knee articulation	3.41	0.81	0.77	—										
2. Activity level	1.77	0.68	0.83	0.56^{**}	—									
Time 2														
3. Symptom and knee articulation	4.50	0.86	0.79	0.29^{**}	0.36^{**}	—								
4. Activity level	2.59	0.91	0.86	0.21^{*}	0.32^{**}	0.62^{**}	—							
Time 3														
5. Symptom and knee articulation	4.73	0.72	0.82	0.27^{**}	0.40^{**}	0.91^{**}	0.64^{**}	—						
6. Activity level	2.98	0.76	0.88	0.19^{*}	0.32^{**}	0.58^{**}	0.84^{**}	0.70^{**}	—					
7. Symptoms	82.49	9.02	0.84	0.22^{*}	0.37^{**}	0.78^{**}	0.69^{**}	0.89^{**}	0.78^{**}	—				
8. Work	88.81	5.35	0.75	0.10	0.24^{**}	0.62^{**}	0.49^{**}	0.70^{**}	0.60^{**}	0.76^{**}	—			
9. Recreational activity	81.26	8.53	0.94	0.13	0.32^{**}	0.69^{**}	0.66^{**}	0.79^{**}	0.73^{**}	0.91^{**}	0.74^{**}	—		
10. Lifestyle	82.45	7.75	0.91	0.25^{**}	0.38^{**}	0.71^{**}	0.63^{**}	0.81^{**}	0.71^{**}	0.90^{**}	0.69^{**}	0.82^{**}	—	
11. Social and emotional	78.22	9.51	0.84	0.26^{**}	0.38^{**}	0.72^{**}	0.67^{**}	0.83^{**}	0.73^{**}	0.87^{**}	0.63^{**}	0.79^{**}	0.84^{**}	—

$^{*}P < .05$;
$^{**}P < .01$.

ACL-QOL subscales. Finally, at 2-9 years post-surgery, SKA was significantly associated with all five ACL-QOL subscales, but AL was only associated with one, recreational activity. To the best of our knowledge, no other studies to date have demonstrated that higher activity level with regard to knee function before surgery is associated with better quality of life. However, there is some support for our findings regarding symptoms and knee articulation. Specifically, negative symptoms, such as persistent pain (eg,[27]) and post-traumatic osteoarthritis (eg,[23-28]), have been shown to adversely affect health-related quality of life after ACL reconstruction.

Beyond these findings, the results pertaining to the association between patient-reported knee function and knee-related quality of life have been inconsistent. For example, Möller et al[14] found no correlation between patient-reported knee function (as measured by the Lysholm, Tegner, and SF-36 health survey) and knee-related quality of life (as measured by the Knee Injury and Osteoarthritis Outcome Score, KOOS). However, this may be due to the measures adopted, rather than the relationship between the subjective measures of knee function and quality of life, as the choice of quality of life measure can have a substantial impact on the interpretation of the results.[13] Studies that have used the knee-specific KOOS have reported poorer knee-related quality of life, compared with published population norms.[29,30] In contrast, studies adopting the generic SF-36 have typically reported similar, or in some cases, higher knee-related quality of life scores than age-equivalent population norms.[31,32] At present, only a small number of studies (eg, [12,33]) have used the ACL-QOL, which makes comparisons across studies difficult. Furthermore, large discrepancies between mean ACL-QOL scores reported in the present study (M = 83), and those of Filbay et al[12] (M = 57) and Otts et al[33] (M = 78) highlight the importance of additional research employing the ACL-QOL to facilitate meaningful comparison of findings across studies.

Irrespective of the type of measures used, results from this study suggest that developing a greater understanding of patients' perceptions of their knee function prior to reconstructive surgery and before being formally discharged from physiotherapy (typically around 6 months) may assist clinicians to identify patients at increased risk of poor long-term knee-related quality of life. Early identification allows time for clinicians to educate patients about potential long-term outcomes following ACL reconstruction, and to develop strategies for optimizing post-operative knee-related quality of life, such as restoring confidence in the knee and making healthy lifestyle modifications.[13]

Despite adopting repeated assessments of the IKDC and utilizing Bayesian estimation to confirm the factor structure and the hypothesized relationships between perceived knee function and quality of life, there are some limitations worth considering when interpreting the present findings. First, the low response rate at Time 3 (only 41% of Time 1 participants completed Time 2 and 3 measures), the high mean ACL-QOL scores, and the significant baseline differences in knee function suggest that only people who experienced favorable outcomes participated in the study. A second limitation associated with this study is the potential effect of common method variance which can arise when self-report questionnaires are used to measure both the predictor (IKDC) and criterion (ACL-QOL) variables. Common methods can cause systematic measurement errors that either inflate or deflate the observed relationships between constructs, generating both Type I and Type II errors.[34,35] The temporal separation between measures of knee function (specifically at Time 1 and 2) and quality of life (Time 3) helped control for method bias.[36-38] Furthermore, the variations in the results for different predictor and criterion variables suggest that common method variance was not a serious concern in this study. Finally, given that only patients from a single surgeon were included, these findings may not be generalizable to individuals undergoing reconstructive surgery in other orthopedic settings.

In order to overcome these limitations, future investigations should consider adopting purposeful sampling procedures, such as those adopted by Filbay et al,[12] and more objective indices of knee function (eg, hop tests) alongside subjective measures to negate the effects of common methods bias and ensure a comprehensive examination of patients' knee function and quality of life following ACL reconstruction. Furthermore, it is likely that patients' knee-related quality of life might fluctuate throughout the rehabilitation period following ACL reconstruction. Yet, our understanding of potentially important temporal changes is limited by the predominance of cross-sectional research in this area. Evidently, longitudinal, repeated-measures designs should be adopted in future research.

5 | CONCLUSION

In conclusion, a prominent concern for healthcare professionals is ensuring better knee-related quality of life following ACL reconstruction. At present, our understanding of factors associated with such improvements is limited, with only recent research attention devoted to patients' long-term quality of life. Results from this study suggest there might be an important relationship between patients' perceived knee function and quality of life, but future investigations should examine additional factors, including those of a psychosocial nature to enhance our understanding of, and safeguard greater knee-related post-surgical quality of life.

6 | PERSPECTIVES

The Bayesian confirmatory factor analysis demonstrated Higgins et al's[7] two-factor structure, representing symptom and knee articulation (SKA) and activity level (AL), was the best fit to the data across each of the three time-points in a homogenous sample of ACL participants. While the original conceptualization of the IKDC might provide clinicians with a convenient total score to represent symptoms, activities, and function, in effect an aggregated score may in fact mask deficits in one of these domains.[8] Indeed, this was exemplified in the findings from the second aim of the study, in which the multifactorial structure of the IKDC revealed important differences when examining patients' knee-related quality of life. Specifically, the findings revealed that pre-surgery AL significantly predicted each of the ACL-QOL subscales, whereas pre-surgery SKA did not predict any of the ACL-QOL subscales. In contrast, at 2-9 years post-surgery SKA significantly predicted each of the ACL-QOL subscales, while AL only predicted one. These exploratory findings, which add to what is at present, a very limited understanding of the factors associated with patients' quality of life following ACL reconstruction, have implications for future hypothesis generation within this area of research. Moreover, given the associations between pre-surgery AL and the ACL-QOL subscales, these findings speak to the need to control for pre-surgery values in future prospective studies. Such research endeavors may, ultimately, assist clinicians to identify patients at increased risk of poor long-term quality of life following ACL reconstruction—allowing them time to educate patients about potential long-term outcomes, and develop strategies for optimizing post-operative quality of life.[13]

CONFLICT OF INTERESTS

None declared.

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